

## CLAIMS

What is claimed is:

1. An optical information recording apparatus for recording  
5 information in an optical information recording medium having an  
information recording layer in which information is recorded  
utilizing holography, the apparatus comprising:
- information light generation means for generating  
information light carrying information;
- 10 recording reference light generation means including phase  
modulation means for spatially modulating the phase of light, for  
generating reference light for recording having a phase spatially  
modulated by the phase modulation means; and
- a recording optical system for illuminating the information  
15 recording layer on the same side thereof with the information light  
generated by the information light generation means and the  
reference light for recording generated by the recording  
reference light generation means such that the information is  
20 recorded in the information recording layer in the form of an  
interference pattern as a result of interference between the  
information light and the reference light for recording.
2. An optical information recording apparatus according to  
claim 1, wherein the optical information recording medium has a  
positioning region for recording information for positioning the  
25 information light and the reference light for recording, the  
apparatus further comprising position control means for

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1. The first step is to identify the problem or goal. This involves understanding the current situation and what needs to be achieved.

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reference light for recording having a spatially modulated phase;  
and

5 illuminating the information recording layer on the same  
side thereof with the information light and the reference light  
for recording to record the information in the information  
recording layer in the form of an interference pattern as a result  
of interference between the information light and the reference  
light for recording.

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7. An optical information reproducing apparatus for  
10 reproducing information utilizing holography from an optical  
information recording medium having an information recording  
layer in which the information is recorded in the form of an  
interference pattern as a result of interference between  
information light carrying the information and reference light  
15 for recording having a spatially modulated phase, the apparatus  
comprising:

20 reproduction reference light generation means including  
phase modulation means for spatially modulating the phase of light,  
for generating reference light for reproduction having a phase  
spatially modulated by the phase modulation means;

a reproducing optical system for illuminating the  
information recording layer with the reference light for  
reproduction generated by the reproduction reference light  
generation means and for collecting reproduction light generated  
25 at the information recording layer when illuminated with the  
reference light for reproduction on the same side of the

information recording layer that is illuminated with the reference light for reproduction; and

detection means for detecting the reproduction light collected by the reproducing optical system.

5        8. An optical information reproducing apparatus according to claim 7, wherein the optical information recording medium has a positioning region for recording information for positioning the reference light for reproduction, the apparatus further comprising position control means for controlling the position  
10 of the reference light for reproduction relative to the optical information recording medium using the information recorded in the positioning region.

9. An optical information reproducing apparatus according to claim 7, wherein the reproducing optical system projects the  
15 reference light for reproduction and collects the reproduction light such that the optical axis of the reference light for reproduction and the optical axis of the reproduction light are located on the same line.

10. An optical information reproducing apparatus according to claim 7, wherein the reproduction reference light generation  
20 means generates the reference light for reproduction in a plurality of wavelength bands, and the detection means detects the reproduction light in the same plurality of wavelength bands.

11. An optical information reproducing method for  
25 reproducing information utilizing holography from an optical information recording medium having an information recording

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5 comprising the steps of:

10 illuminating the information recording layer with the reference light for reproduction and collecting reproduction light generated at the information recording layer when illuminated with the reference light for reproduction on the same side of the information recording layer that is illuminated with the reference light for reproduction; and

15 detecting the collected reproduction light.

20 position of a wavelength of incident light and in which information  
is recorded utilizing holography, the apparatus comprising:

wavelength selection means for selecting a wavelength of light illuminating the information recording layer from among a plurality of wavelengths;

25            information light generation means for generating  
             information light having the wavelength selected by the

recording reference light generation means for generating reference light for recording having the wavelength selected by the wavelength selection means; and

13. An optical information recording apparatus according to claim 12, wherein the optical information recording medium has a positioning region for recording information for positioning the information light and the reference light for recording, the apparatus further comprising position control means for controlling the positions of the information light and the reference light for recording relative to the optical information recording medium using the information recorded in the positioning region.

14. An optical information recording apparatus according to claim 12, wherein the recording optical system projects the information light and the reference light for recording such that the optical axis of the information light and the optical axis of the reference light for recording are located on the same line.

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reproduction reference light generation means for  
generating reference light for reproduction having the wavelength  
selected by the wavelength selection means;

1. The first part of the paper is devoted to the study of the properties of the function  $f(x)$  defined by the equation  $f(x) = \int_0^x f(t) dt$ . It is shown that  $f(x)$  is a continuous function and that it satisfies the functional equation  $f(x+y) = f(x) + f(y)$ .

detection means for detecting the reproduction light collected by the reproducing optical system.

17. An optical information reproducing apparatus according to claim 16, wherein the optical information recording medium has a positioning region for recording information for positioning the reference light for reproduction, the apparatus further comprising position control means for controlling the position of the reference light for reproduction relative to the optical information recording medium using the information recorded in the positioning region.



18. An optical information reproducing apparatus according to claim 16, wherein the reproducing optical system projects the reference light for reproduction and collects the reproduction light such that the optical axis of the reference light for reproduction and the optical axis of the reproduction light are located on the same line.

19. An optical information reproducing method for reproducing information utilizing holography from an optical information recording medium having an information recording layer in which the information is recorded in the form of an interference pattern as a result of interference between information light having a wavelength selected from among a plurality of wavelengths and carrying the information and reference light for recording having the wavelength selected from among a plurality of wavelengths, the method comprising the steps of:

selecting a wavelength of light illuminating the information recording layer from among a plurality of wavelengths;

generating reference light for reproduction having the selected wavelength;

illuminating the information recording layer with the reference light for reproduction and collecting reproduction light generated at the information recording layer when illuminated with the reference light for reproduction on the same side of the information recording layer that is illuminated with

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the information light C and the reference light for recording.

21. An optical information recording apparatus according to claim 20, wherein the optical information recording medium has a positioning region for recording information for positioning  
5 the information light and the reference light for recording, the apparatus further comprising position control means for controlling the positions of the information light and the reference light for recording relative to the optical information recording medium using the information recorded in the  
10 positioning region.

22. An optical information recording apparatus according to claim 20, wherein the recording optical system projects the information light and the reference light for recording such that the optical axis of the information light and the optical axis  
15 of the reference light for recording are located on the same line.

23. An optical information recording method for recording information in an optical information recording medium having an information recording layer in which a change in absorbance occurs  
in an absorption spectrum thereof in the position of a wavelength  
20 of incident light and in which information is recorded utilizing holography, the method comprising the steps of:

selecting a wavelength of light illuminating the information recording layer from among a plurality of wavelengths;

25 generating information light having the selected wavelength and carrying information;

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spatially modulating the phase of light to generate reference light for recording having the selected wavelength and a spatially modulated phase; and

illuminating the information recording layer on the same side thereof with the information light and the reference light for recording to record the information in the information recording layer in the form of an interference pattern as a result of interference between the information light and the reference light for recording.

24. An optical information reproducing apparatus for reproducing information utilizing holography from an optical information recording medium having an information recording layer in which the information is recorded in the form of an interference pattern as a result of interference between information light having a wavelength selected from among a plurality of wavelengths and carrying the information and reference light for recording having the wavelength selected from among a plurality of wavelengths and having a spatially modulated phase, the apparatus comprising:

wavelength selection means for selecting a wavelength of light illuminating the information recording layer from among a plurality of wavelengths;

reproduction reference light generation means including phase modulation means for spatially modulating the phase of light, for generating reference light for reproduction having the wavelength selected by the wavelength selection means and having

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a phase spatially modulated by the phase modulation means;

5 a reproducing optical system for illuminating the information recording layer with the reference light for reproduction generated by the reproduction reference light generation means and for collecting reproduction light generated at the information recording layer when illuminated with the reference light for reproduction on the same side of the information recording layer that is illuminated with the reference light for reproduction; and

10 detection means for detecting the reproduction light collected by the reproducing optical system.

25. An optical information reproducing apparatus according to claim 24, wherein the optical information recording medium has a positioning region for recording information for positioning the reference light for reproduction, the apparatus further comprising position control means for controlling the position of the reference light for reproduction relative to the optical information recording medium using the information recorded in the positioning region.

20 26. An optical information reproducing apparatus according to claim 24, wherein the reproducing optical system projects the reference light for reproduction and collects the reproduction light such that the optical axis of the reference light for reproduction and the optical axis of the reproduction light are  
25 located on the same line.

27. An optical information reproducing method for

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reproducing information utilizing holography from an optical information recording medium having an information recording layer in which the information is recorded in the form of an interference pattern as a result of interference between  
 5 information light having a wavelength selected from among a plurality of wavelengths and carrying the information and reference light for recording having the wavelength selected from among a plurality of wavelengths and having a spatially modulated phase, the method comprising the steps of:

10        selecting a wavelength of light illuminating the information recording layer from among a plurality of wavelengths;

spatially modulating the phase of light to generate reference light for reproduction having the selected wavelength  
 15        and a spatially modulated phase;

             illuminating the information recording layer with the reference light for reproduction and collecting reproduction light generated at the information recording layer when  
 20        illuminated with the reference light for reproduction on the same side of the information recording layer that is illuminated with the reference light for reproduction; and

detecting the collected reproduction light.

28. An optical information recording apparatus for recording information in an optical information recording medium  
 25        having an information recording layer in which information is recorded utilizing holography, the apparatus comprising:

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a pick-up device provided in a face-to-face relationship with the optical information recording medium, the pick-up device having:

a light source for emitting beams of light;

5 information light generation means for spatially modulating the beams of light emitted by the light source to generate information light carrying information;

recording reference light generation means for generating reference light for recording using the beams of light emitted  
10 by the light source; and

a recording optical system for illuminating the information recording layer on the same side thereof with the information light generated by the information light generation means and the reference light for recording generated by the recording  
15 reference light generation means such that the information is recorded in the information recording layer in the form of an interference pattern as a result of interference between the information light and the reference light for recording.

29. An optical information recording apparatus according to  
20 claim 28, wherein the recording optical system projects the information light and the reference light for recording such that the optical axis of the information light and the optical axis of the reference light for recording are located on the same line.

30. An optical information recording apparatus according  
25 to claim 28, wherein the light source emits the beams of light in a plurality of wavelength bands.

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31. An optical information recording apparatus according to claim 28, wherein the pick-up device has first light quantity monitoring means for monitoring the quantity of the information light and second light quantity monitoring means for monitoring the reference light for recording.

32. An optical information recording apparatus according to claim 28, wherein the pick-up device has reproduction light detection means for detecting reproduction light generated as a result of diffraction of the reference light for recording caused by an interference pattern formed in the information recording layer when the information is recorded in the information recording layer.

33. An optical information recording apparatus according to claim 32, further comprising control means for controlling a recording operation based on information of the reproduction light detected by the reproduction light detection means.

34. An optical information recording apparatus according to claim 32, further comprising control means for controlling illuminating conditions for the information light and the reference light for recording during multiplex recording based on information of the reproduction light detected by the reproduction light detection means.

35. An optical information recording apparatus according to claim 28, wherein the pick-up device has fixing means for fixing the information recorded in the form of an interference pattern in the information recording layer.

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36. An optical information recording apparatus according to claim 28, wherein the optical information recording medium has: a recording region where the information can be recorded in the form of an interference pattern; and positioning regions provided on both sides of the recording region for positioning the information light and the reference light for recording, the apparatus further comprising control means for reciprocating illuminating positions of the information light and the reference light for recording by way of the recording region and at least a part of the positioning regions on both sides thereof so as to position the information light and the reference light for recording relative to the recording region based on information obtained from the positioning regions.

37. An optical information recording apparatus according to claim 28, comprising a plurality of the pick-up devices.

38. An optical information reproducing apparatus for reproducing information from an optical information recording medium having an information recording layer with information recorded therein utilizing holography, the apparatus comprising: a pick-up device provided in a face-to-face relationship with the optical information recording medium, the pick-up device having:

a light source for emitting beams of light;  
reproduction reference light generation means for generating reference light for reproduction using the beams of light emitted by the light source;

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a reproducing optical system for illuminating the  
 information recording layer with the reference light for  
 reproduction generated by the reproduction reference light  
 generation means and for collecting reproduction light generated  
 5 at the information recording layer when illuminated with the  
 reference light for reproduction on the same side of the  
 information recording layer that is illuminated with the  
 reference light for reproduction; and

10 detection means for detecting the reproduction light  
 collected by the reproducing optical system.

39. An optical information reproducing apparatus according  
 to claim 38, wherein the reproducing optical system projects the  
 reference light for reproduction and collects the reproduction  
 light such that the axis of the reference light for reproduction  
 15 and the axis of the reproduction light are located on the same  
 line.

40. An optical information reproducing apparatus according  
 to claim 38, wherein the light source emits the beams of light  
 in a plurality of wavelength bands, and the detection means detects  
 20 the reproduction light in the same plurality of wavelength bands  
 as those of the beams of light emitted by the light source.

41. An optical information reproducing apparatus according  
 to claim 38, wherein the pick-up device has light quantity  
 monitoring means for monitoring the quantity of the reference  
 25 light for reproduction.

42. An optical information reproducing apparatus according

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to claim 38, wherein the optical information recording medium has:  
 a recording region where information is recorded in the form of  
 an interference pattern; and positioning regions provided on both  
 sides of the recording region for positioning the reference light  
 5 for reproduction, the apparatus further comprising control means  
 for reciprocating illuminating positions of the reference light  
 for reproduction by way of the recording region and at least a  
 part of the positioning regions on both sides thereof so as to  
 position the reference light for reproduction relative to the  
 10 recording region based on information obtained from the  
 positioning regions.

43. An optical information reproducing apparatus according  
 to claim 38, comprising a plurality of the pick-up devices.

44. An optical information recording/reproducing  
 15 apparatus for recording information in an optical information  
 recording medium having an information recording layer in which  
 information is recorded utilizing holography and for reproducing  
 the information from the optical information recording medium,  
 the apparatus comprising a pick-up device provided in a face-  
 20 to-face relationship with the optical information recording  
 medium, the pick-up device having:

a light source for emitting beams of light;  
 information light generation means for generating  
 information light carrying information by spatially modulating  
 25 the beams of light emitted by the light source;  
 recording reference light generation means for generating

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form of an interference pattern as a result of interference between information light and reference light for recording utilizing holography and for generating reproduction light associated with the recorded information when illuminated with reference light

5 for reproduction; and

a second information layer which is provided in a position different from the position of the first information layer in the direction of the thickness and in which information is recorded using means different from that for the recording of information  
10 in the first information layer.

47. An optical information recording medium according to claim 46, wherein information for positioning the information light, the reference light for recording and the reference light for reproduction is recorded in the second information layer.

15 48. An optical information recording medium according to claim 46, wherein a gap having a predetermined thickness is formed between the first and second information layers.

49. An optical information recording medium according to claim 48, further comprising a spacer for separating the first  
20 and second information layers with a predetermined interval between them to form the gap.

50. An optical information recording medium according to claim 48, further comprising a transparent substrate provided between the first and second information layers to form the gap.

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